DOCUMENT RESUME

ED 080 447 SP 005 743

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TITLE A New Kit of Tools for Designing Instruction.
INSTITUTION Rand Corp., Santa Monica, Calif.
SPONS AGENCY Air Force Directorate of Operational Requirements and Development Plans, Washington, D.C.
REPORT NO R-1018-PR
PUB DATE Mar 72
NOTE 13p.; Paper presented at the Annual Meeting of the American Educational Research Association, Chicago, Ill., April 1972

EDRS PRICE MF-$0.65 HC-$3.29
DESCRIPTORS *Curriculum Design; Educational Research; *Educational Strategies; Input Output Analysis; *Instructional Design; Instructional Innovation; *Instructional Systems; *Systems Analysis

ABSTRACT

Design tools used for instructional planning can be described in terms of inputs, outputs, major components, and their interrelations. The outputs are course length; student flow; and requirements for resources, such as facilities, material, personnel, and dollars. The inputs are the teaching institution, learners for whom the course was designed, and the course objectives. The major steps in planning the design are to characterize learners in terms of teaching methods and techniques, to state a general instructional policy after the analysis of learner population, and to analyze the curriculum. From these steps, specific strategies are developed based on design criteria, local resources, and student loads. (Four figures of the design process are included.) (BRB)

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R-1018-PR

A NEW KIT OF TOOLS FOR DESIGNING INSTRUCTION

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March 1972

This research is supported by the United States Air Force under Project Rand -- Contract No. F44620-67-C-0045 -- Monitored by the Directorate of Operational Requirements and Development Plans, Deputy Chief of Staff, Research and Development, Hq USAF. Views or conclusions contained in this study should not be interpreted as representing the official opinion or policy of Rand or of the United States Air Force.

PREFACE

This is the first of four interrelated reports contributed to a symposium held during the American Educational Research Association Convention in Chicago during the first week in April 1972. The other reports in the group are:

R-1019-PR, *A Decision Process for Developing Strategies of Instruction*, by Polly Carpenter

R-1020-PR, *A Structured Questionnaire for Describing Learning Events in a Course of Study*, by Rudy Bretz

R-1021-PR, *A Model for Implementing Instructional Strategies Applied to Specific Courses*, by Robert L. Petruschell and Polly Carpenter

Each of these, except the contribution by R. Bretz, is an abridged version of a more comprehensive and detailed report. The abridged versions will be of interest to the general reader; the detailed reports are intended to assist those actually involved in the design process.

The symposium discusses an approach to the design of instructional systems developed by the Rand team under sponsorship of the Air Force. The design methodology is intended to be sufficiently general in nature that it could be used by education planners in any school situation.

THE PROBLEM

Many new ways of teaching and much instructional technology have been developed and validated for their contributions to effective instruction, yet these innovations have seen but little implementation in existing teaching institutions. One of the prime reasons for this is that planners of instruction, even when they are not also burdened with the task of classroom teaching, are (1) not sufficiently familiar with the new systems to plan their implementation and (2) lack tools to assist them in planning the implementation of those systems with which they are familiar.

At present the implementation of innovations in the process of instruction at a teaching institution arises primarily from the efforts of a few people who believe that some particular strategy of instruction or application of new instructional technology will be more effective than methods already in use. If such people succeed in convincing school personnel of the merits of their position, they must either go through a lengthy design process with very little to assist them besides their own convictions, or they must effect the change through trial and error. Their efforts, of necessity, will be directed primarily by intuition and subjective judgment. More effective or less expensive instruction may result, but there is no assurance that it is as effective as it could be, no assurance that other strategies could not be used along with the one of primary interest, no assurance that more desirable combinations of techniques, operating procedures, personnel, materials, and equipment have not been overlooked.

It would be desirable for changes in instruction no longer to be one-shot responses to some researcher's pet theory. Instead, change should be a continuous feature of any viable institution that serves the social, economic, and technological needs of the future. The objective of the research we shall describe today is to facilitate change by developing a kit of tools for the design of systems for instruction. These tools will permit the education planner rapidly to assess the utility of a particular instructional approach. If the approach then appears to have unacceptable flaws, he may quickly construct and assess an alternative approach. By providing this kind of feedback, the process will help

assure that many promising approaches are "tried out," so to speak, before one is chosen for actual implementation.

As suggested, the design of instruction draws primarily on the judgment of people in the schools--judgment that is shaped largely by the schools' facilities, equipment, operating practices, and materials, and by available personnel. The tool kit helps the planner to externalize these judgments so that they may direct design in an orderly fashion. Thus, the professional experience of the educator becomes an integral part of the design process. In addition, the current state of affairs is such that some features that are crucial to the design of instruction are not explicitly considered before teaching is actually under way. The tool kit also helps the planner take such characteristics into account in designing his course by providing a checklist of items that should be thought about.

We term these *tools* because every attempt has been made to avoid prescribing *who* is to be taught *what* and *how*. Instead, given that the planner has established his own general policies on these matters, the tools should help him to "get there from here." This is a tool *kit* because each tool supplies something that can be used by the others. Even so, each tool is useful in its own right because each externalizes and delineates features of the instructional process that direct teaching in the classroom or workshop.

Whom do we see as the users of these tools? Ultimately, they should be people in the schools who are responsible for the selection, design, and implementation of new instructional programs. Such people are found in the administrative offices of large school districts, in such military counterparts as the training research applications groups in the Air Force, and in the teams that develop instructional systems for firms in the education industry. Hopefully, as tools are more fully developed for instructional system design, people of these kinds will be able to tailor instruction more precisely to the needs of learners and schools.

This work has been supported by the Air Force, in which we find a wide variety of institutions for education and training--from training pilots to pursuit of higher degrees. To assure the relevance of the design methodology to all of these schools, we have directed our efforts toward applications that will be of use to a varied audience including also those in elementary and secondary education and vocational training.

THE GENERAL APPROACH

The purpose of this Symposium is to describe several of the tools to make them more accessible to people involved with the theory and practice of instructional system design and to provide a vehicle for critical comment. The tools we shall discuss are key elements in the set of methodologies for planning and designing instructional systems. The overall process of instructional system design will now be described to provide a framework for the Symposium. The process will be described in terms of inputs, outputs, major components, and their interrelations.

A description of the outputs will illustrate the direction of our efforts in specific terms. They are the following characteristics of an instructional system: course length; student flow, as a function of time during the course; and requirements for resources, such as facilities, material, equipment, personnel, and dollars (see Fig. 1). The outputs will also show variations in resource requirements during the phases of implementation and operation of the course.

These outputs will be related to the inputs, which we characterize in three general areas: the teaching institution, learners for whom the course of study is intended, and the course objectives. Throughout, it is assumed that the learning objectives of the course have already been determined. The step on which Rand has been working is the point at which actual instruction must be planned and implemented for validation.

The design process is intended to relate outputs to inputs so that the outputs will be acceptable to the teaching institution, and so that the instructional system they describe will teach the course of study to the designated learners. We have made some progress in identifying the steps in the design process, determining their sequence, and discovering their interrelationships. The results of this work will provide school personnel with tools that will both make it easier for them to design new instructional systems and will help assure that their designs are comprehensive, coherent, and appropriate to their needs. We plan to automate parts of the design process so that it will take a matter of a few weeks or perhaps even a few days, rather than taking, say, several months to a year as it does at present. This will allow planners to consider several possible alternative ways to conduct a particular course so that they may choose the way that is most promising.

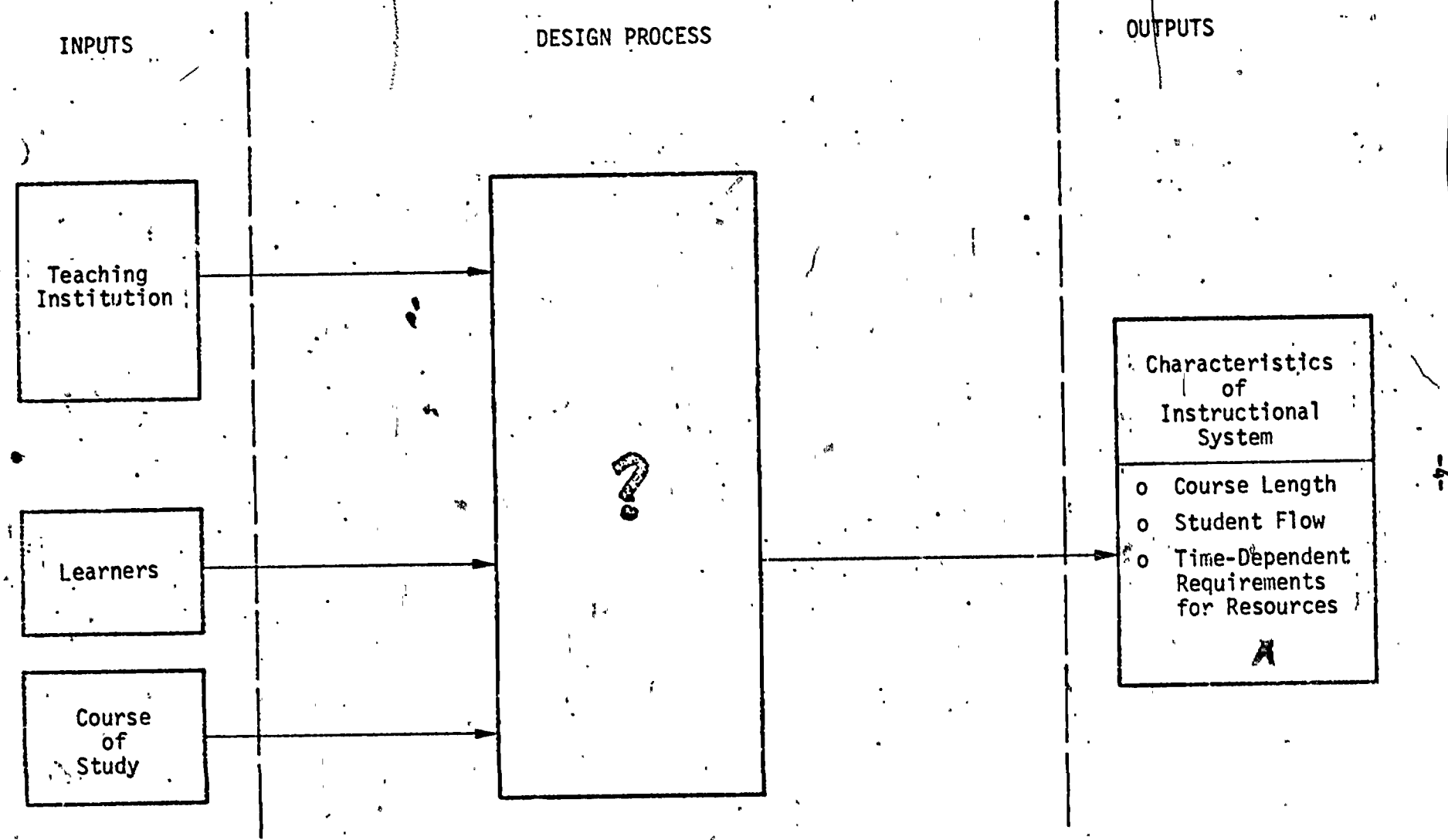

Fig. 1--Framework of design process

To our knowledge, a comprehensive methodology for instructional system design has not been devised. Thus, the work is not only challenging but an exciting pioneering effort.

The first step is to characterize the learners in terms that will affect the way the course will be taught (step 1, Fig. 2). For example, some learners may have already had experience in the particular field in which they will be studying and will not need to study some parts of the curriculum. The second step, we believe, is to state general policy (step 2, Fig. 2). This is accomplished by having the planner answer a simple questionnaire, to be described shortly.* The statement of general policy can be heavily influenced by the analysis of the learner population.

The third step, the Curriculum Analysis, is denoted step 3a (Fig. 3) because it is interrelated with the next step. This analysis is a branching questionnaire and will be described by R. Bretz immediately after my presentation.** It guides the user in providing a detailed description of his course of study. First, it categorizes each topic in the curriculum in "system-oriented" terms, such as whether the instruction must be given in a classroom or in a laboratory, whether it requires special equipment, or whether it requires a monitor to ensure student safety.

The Curriculum Analysis also characterizes each topic's requirements for communication media. We have focused on communication media for two reasons. First, media are playing an increasingly important role in education. Second, many people are unfamiliar with media and their uses and are looking for guidance in this area, which we believe we can provide.*** However, the design methodology does *not* specify that communication media must be used for every topic even though the Curriculum Analysis describes possible requirements for communication media for every topic.

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*Polly Carpenter, *A Decision Process for Developing Strategies of Instruction*, The Rand Corporation, R-1019-PR, March 1972.

**Rudy Bretz, *A Structured Questionnaire for Describing Learning Events in a Course of Study*, The Rand Corporation, R-1020-PR, March 1972.

***Rudy Bretz, *Selection of Appropriate Communication Media for Instruction*, The Rand Corporation, R-601-PR, February 1971.

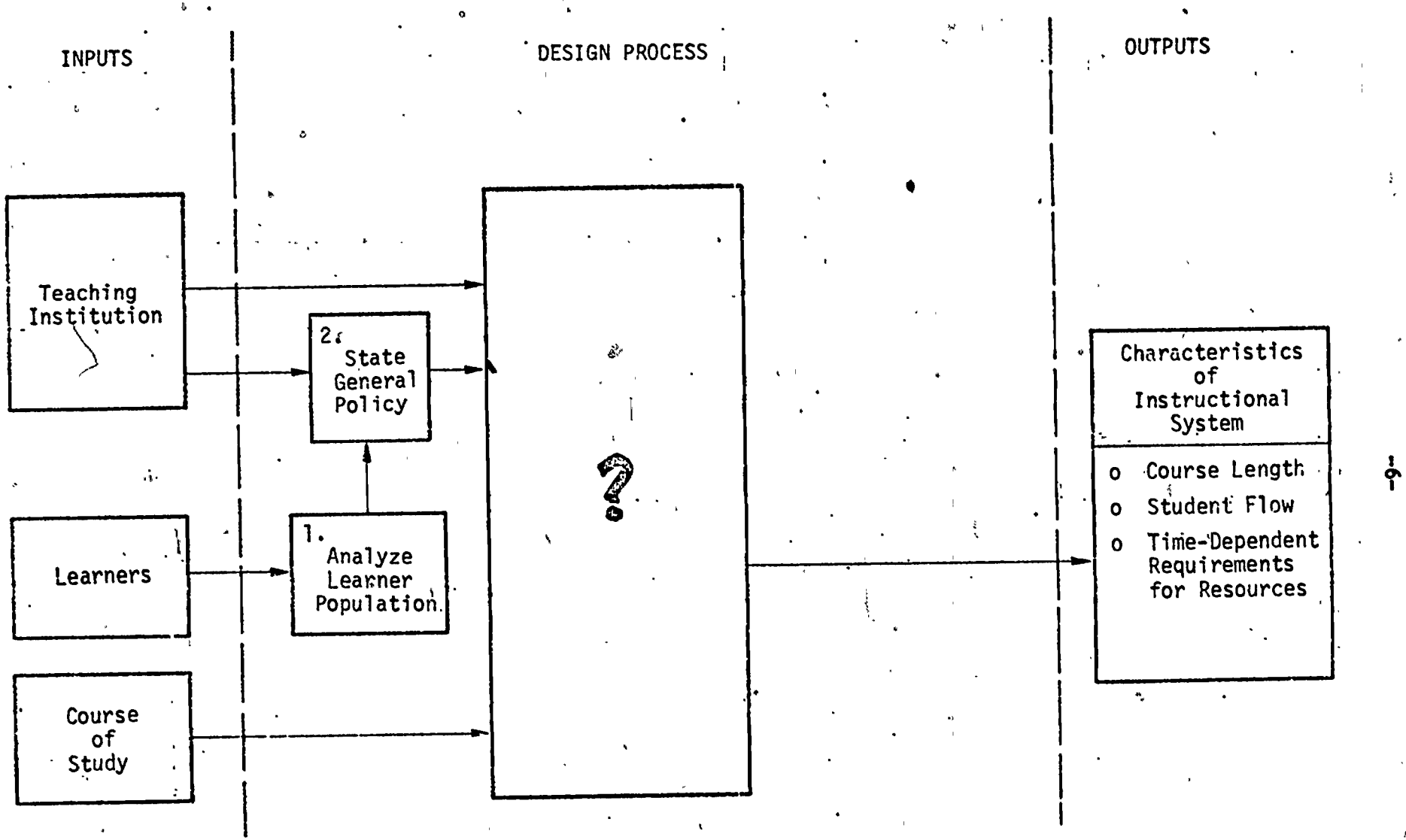

Fig. 2--First steps

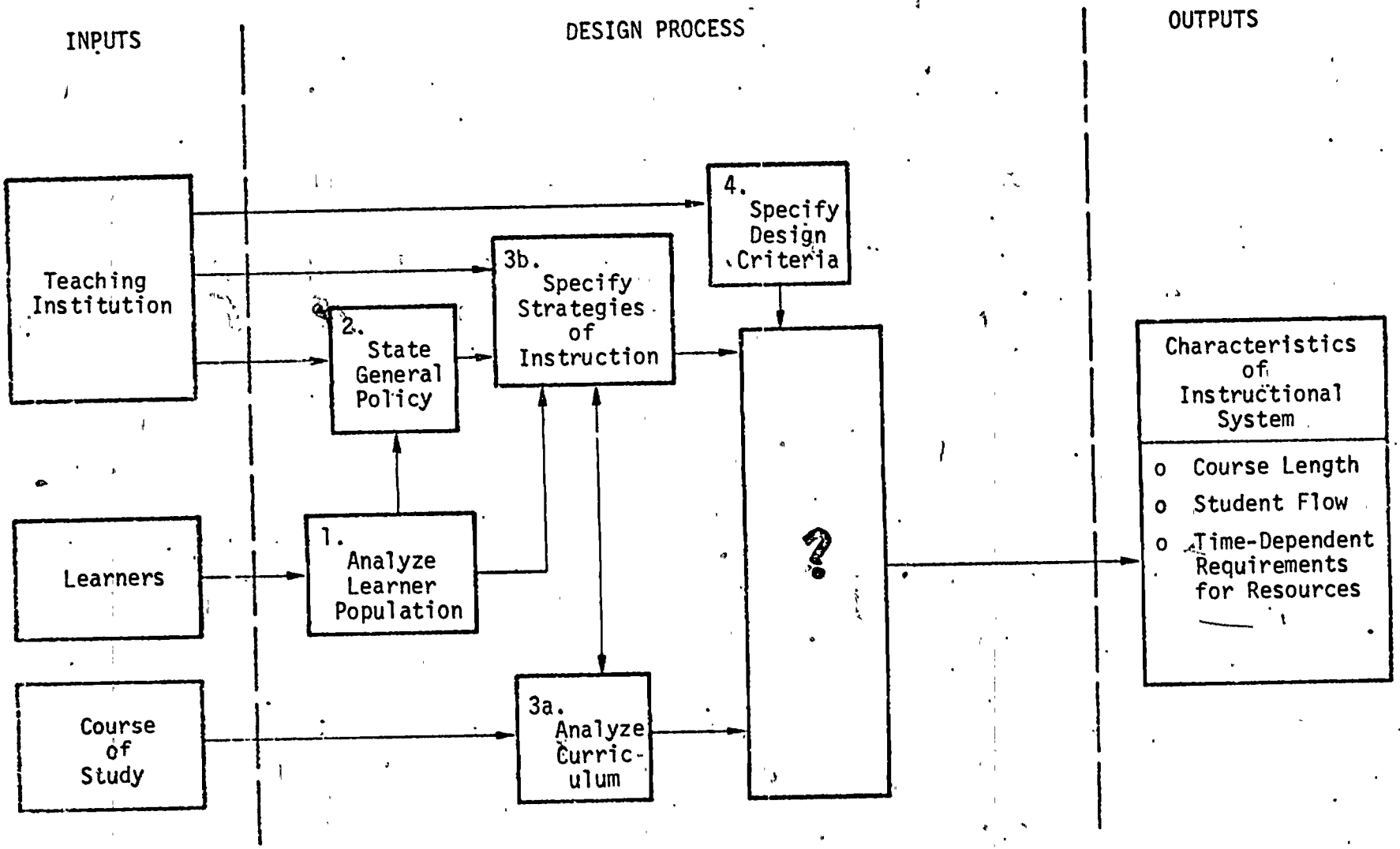

Fig. 3--Setting the stage

The next step will be the main subject of the discussion that I will give following this introductory material. It is the process for specifying strategies of instruction, step 3b. This process is a logic tree, with each decision point a logical consequence of the decisions that have preceded it. To exercise it, the designer will have two aids--an interactive computer program written in JOSS* and a manual that presents the pros and cons of the decisions to be made at each point along with some of the logical consequences of each choice.

Step 3b is the point at which specifications of instructional method are explicitly entered into the design process. The purpose of this step is to encourage the planner to consider the bulk of methods he may wish to use and to translate his decisions into guidelines for system design. Thus, the process is *not* prescriptive in the sense that it champions no particular instructional method. Rather, it attempts to allow the planner to select and apply any method he may think appropriate, from the formal lecture to student-directed role-playing.

The specification of strategies of instruction interacts closely with the Curriculum Analysis (see Fig. 3). At the same time, the framework for this specification is provided by the statement of general policy as well as by indirect input from the teaching institution.

As used here, a strategy of instruction has two dimensions. For each type of instruction identified in the Curriculum Analysis, it specifies (1) whether a person or medium will be teaching, and (2) how students will interact with this teaching. Shortly, I shall discuss the way in which answers to these two questions specify a teaching method.** The strategy also permits specification of details of the use of media or personnel for each type of instruction, such as the level of skill the personnel should have.

Step 4, Fig. 3, establishes a set of design criteria, input from the teaching institution. They will be of the following sort: least

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*Rand's on-line, interactive computer system.

**Carpenter, op. cit.

cost, shortest course length, graduation of the most students per unit time, or maximum use of communication media. The planner would assign each criterion an order of importance or a weight.

Next, data describing the rate of student entry and the school's resources and constraints will also be gathered by means of a logically structured set of questions (step 5). These data will include the number of classrooms, laboratories, or other facilities available; the existence of communication equipment such as television receivers installed in the classrooms; the geographical distribution of students, that is, whether they are all in one building or scattered throughout a campus or city; and the number of instructors available. The resulting description of local resources and student loads will be used in the final design process to specify class size, select specific media systems, and for other purposes.

Now final system design can begin (step 6, Fig. 4). The direct inputs to the design process will be the strategies of instruction, data from the Curriculum Analysis, the design criteria, and the description of local resources. Characteristics of the learner population, the stated general policy, and the general features of the course of study also enter into the design process indirectly.

At present, we see the design process* as having four main components: First, each topic is linked to the strategy of instruction that has been chosen for that particular category of instruction. Second, student flow through the course is simulated by a flow and scheduling model in order to generate graduation rates and resource requirements. Third, a set of criteria is used to select specific media systems. [The Curriculum Analysis only identifies the class of media (for example, motion-visual) that might be used for a particular lesson. What precise form the media system should take (for example, silent 16-mm film) will be specified by the strategies of instruction and other criteria.] Fourth, a set of criteria is used to assign personnel. There

*An example of the application of the design process is described by R. Petruschell and P. Carpenter in *A Model for Implementing Instructional Strategies Applied to Specific Courses*, The Rand Corporation, R-1021-PR, March 1972.

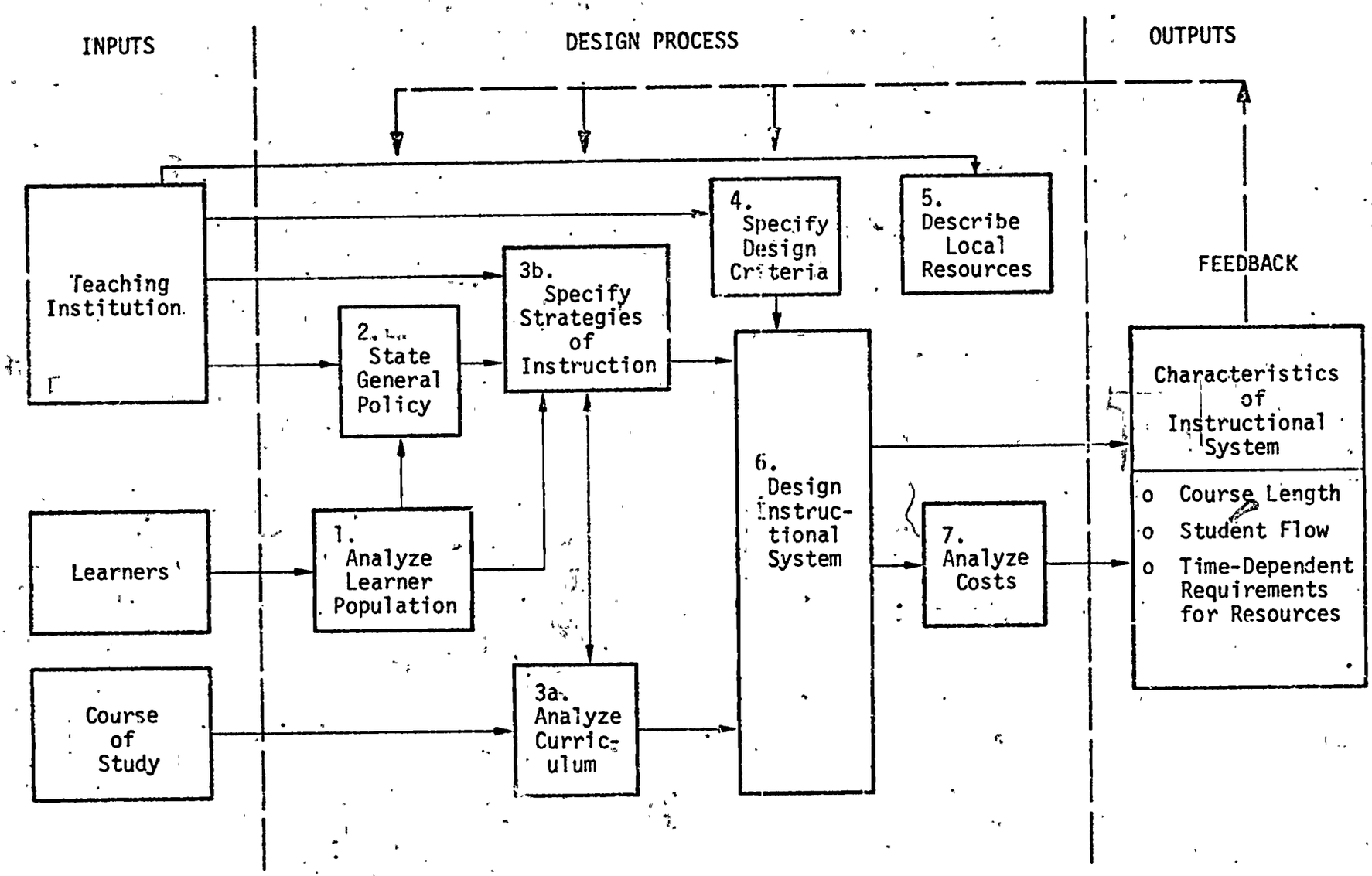

Fig. 4--The design process

will be instances where a certain number of people will be required to carry out a particular task, such as monitoring for safety; other personnel requirements will depend on existing facilities, such as the number of students that can feasibly be assigned to a teacher in a classroom. The final step will be a cost analysis to determine the time-dependent dollar requirements for the system.

As noted above, the outputs of the design process will be course length, student flow, and time-dependent requirements for resources; all are useful for the planner. He can then compare the requirements for resources with the resources he expects to be available to the school to determine whether the system is economically feasible; he can also compare the outputs with requirements for general policy and other inputs to determine whether they are what he wanted. If not, he can change some of the initial specifications such as the strategies of instruction or the design criteria. Possibly, he would want to change the learner population, the course of study, or even the general policy.

Although these tools compose a closely interrelated set of elements for system design, several are useful in their own right. For example, the decision process for setting instructional strategy contains a comprehensive checklist of considerations in instructional system design that can be used without the computer program if so desired. Similarly, the Curriculum Analysis helps the user look at his subject matter in a methodical and systematic manner.